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BY C. GORDON HEWITT, D.Sc.

Dominion Entomologist.

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NOTES ON THE PUPATION OF THE HOUSE-FLY (*MUSCA DOMESTICA*) AND ITS MODE OF OVERWINTERING.*

BY C. GORDON HEWITT, D.SC., DOMINION ENTOMOLOGIST, OTTAWA.

The migratory habit of the larvæ of *Musca domestica* evidenced prior to pupation has been observed by most of the investigators who have studied the insect's life history, and these observations have been collected by Hutchison (1914). Levy and Tuck (1913) appear to be the first workers to call attention to the practical value of this habit in fly control, and Hutchison has extended the work along lines that will undoubtedly provide us with an additional means of control of no little value. The principle involved is the capturing of the mature larvæ leaving the manure to pupate, in accordance with their usual custom, either in the cooler outer portions of the piles or in the subjacent soil.

The migratory habit of the larva has also another interest, namely, its relation to the suppression of flies breeding in the usual type of insanitary privy and in latrines. While a few isolated observations have been made in India and elsewhere I do not know of any exact record of the extent to which the larvæ migrate from the substance in which they have been feeding. Hutchison (l.c.) found that the majority of the pupæ were scattered about the drier margins of the heaps of horse-manure, sheltered by the overhanging straw, and that whereas, in one heap, he found about 9000 pupæ in this position, not more than 100 were found below the soil. In this connection the following observation appears to be worthy of record.

Following the experiments which I carried out (1914) on the control of the larvæ by various insecticides, it was decided to examine the soil around and beneath the untreated and consequently natural heap of horse-manure with a view to ascertaining the distance and depth travelled by the larvæ prior to pupation. Also it was desired to discover whether any of the insects were overwintering in the pupal state; to this aspect of the question I shall return later.

The manure was removed on May 13th and the soil subjacent to and around the site of the pile was carefully removed and an

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approximate record was kept of the numerical abundance of the puparia at the different depths below the surface of the soil to a distance of about four feet around the site. This task was carried out for me by Mr. S. N. Lord, to whom my thanks are due. The results of this examination of the soil, which was a sandy loam, are represented diagramatically in the accompanying figure.

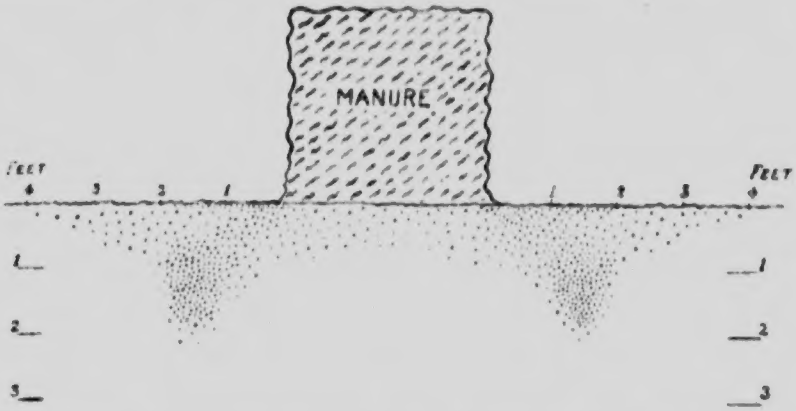

Fig. 7.—Diagrammatic section through heap of manure and subjacent soil to show the migration of the larvæ of *Musca domestica*. The drawing is to scale, distance and depth in feet being indicated. The black dots in the soil represent the puparia. (Original).

A few puparia were found directly beneath the manure pile to a depth of twelve inches. The greatest numbers occurred in the region about eighteen inches from the pile and at a depth of twelve inches to two feet from the surface; this is graphically shown in the figure; the puparia were also numerous immediately below the surface of the soil. The numbers then gradually decreased proportional to the distance from the pile and dwindled away at a distance of about four feet from its base.

This observation is of practical interest to the sanitarian as indicating the habits of the larvæ under normal conditions. It illustrates the ability of the flies to emerge from a depth of two feet as particular attention was paid to condition of the puparia, and the flies had emerged from all the puparia other than those that had failed to develop.

The Overwintering of the House-fly

The question as to the state in which *Musca domestica* passes the winter has been discussed recently by several workers, and it

seems desirable to review the subject again in so far as my experience of conditions in the most northerly temperate latitudes of England and Canada are concerned. In my monograph on the house-fly (1914) the statement is made that three causes contribute to the disappearance of the flies at the end of the summer, namely, retreat into hibernating quarters or into permanently heated places, natural death, and death from *Empusa muscæ*. I must confess that the word "hibernation" has been used in too broad a sense by me, as it has not only implied a dormant state during the winter, which is the usually accepted meaning of the term, but it has also had reference to a possible and sometimes actual state of activity during the winter months. It is in this sense that the word "hibernation" was used, as will be gathered in reading the section under that heading, in the work referred to. It would be preferable to substitute the term "overwintering," as this will adequately cover all conditions and developmental stages and will avoid a possible misuse of the term "hibernation."

Taking all the evidence that is now available, it may be stated that in northerly latitudes *Musca domestica* exists in the overwintering period in the following states.

1. *Dormant.*—In cool retreats where suitable shelter and protection may be found; here flies may truly hibernate.

2. *Periodically active.*—In premises where an increased temperature produces activity in the fly which would otherwise be inactive and dormant.

3. *Permanently active.*—The gradation between the former state, and this would be governed by temperature and the presence of food. Permanently active flies have been found by myself and other observers in every month of the winter season from November to March. I have dissected such flies from December to March and found them capable of reproduction in many instances. Such flies are found in warm bakehouses, kitchens, restaurants and stables. Jepson (1909) used such flies for breeding experiments in February.

4. *In the immature stages.* The previous states, Nos. 1 to 3, are based on actual observations. That in northerly latitudes *M. domestica* may be found in the developmental stages (egg, larva or pupa) is a statement that has only, so far as I know, a theoretical and experimental basis. It should be possible, one would think,

to find *M. domestica* breeding in permanently warm places, such as stables where larval food is present. In many stables, however, the temperatures are very variable, and this fact would lengthen the different stages very considerably. Personally, I have so far failed to discover evidence of *M. domestica* breeding under natural conditions during the winter months in the latitudes of Ottawa (Canada) and England, but observations indicate the possibility of such an occurrence in the presence of suitable conditions.

In the light of the evidence at present available, I think we are still justified in regarding the dormant and periodically active states during the overwintering period as the usual occurrence in northerly latitudes. But there is no doubt that where circumstances render state No. 3 possible, it contributes very materially to an increase in the number of available and active flies early in the spring. I have always held the same view as that suggested by Copeman and Austen (1914b): "That the relative lateness of the season at which house-flies annually become abundant may be due to the smallness of the number of individuals that, in an active condition, survive the winter in houses or other buildings." This idea was supported by my observations in the state of the reproductive organs of a portion of the flies found and dissected during the winter months.

The last contribution to our knowledge on this subject is the report of Copeman and Austen, quoted above, on the results of an examination of the species of flies collected in houses, etc., during the winter months. They state: "In conclusion, it would appear that the customary explanation of the perpetuation of the house-fly from year to year has now been fairly tested, and that the evidence obtained fails to support it. If, however, during the season of greatest fly-prevalence, a selection were made of several centres in which house-flies were present in sufficiently large numbers, it would be worth while during the following winter to endeavour to discover whether living pupae could be found in any considerable quantity in the local breeding-places."

One serious objection prevents my agreement with their conclusion. The evidence contained in their report points to the fact that practically all the specimens of *M. domestica* that were received were caught in an active condition, and there is no evidence submitted to show that any of their correspondents found

these flies as a result of searching for them in the hiding places from which Jepson and I have recorded them. In view of this objection the facts submitted by Copeman and Austen cannot be fairly considered as failing to support the explanation usually given. I may say I have repeatedly applied the test they suggest, and in no case have I been able to find either in England or Canada living pupæ of *M. domestica* under outdoor conditions during the winter. Nor has it ever been possible in my breeding experiments in Canada and in Englaad to carry the insect through the winter in the pupal state. In the experiment described in the first part of this paper a special effort was made to find living puparia among several thousand examined, and not a single healthy puparium was discovered; all were either empty or had failed to develop. Had specimens been overwintering in the pupal condition, it is reasonable to expect that living puparia would have been found in the early part of May, as the adults could not have emerged earlier than that date under Ottawa conditions. It is a matter, however, that requires more observations in different localities, but until evidence is secured of the insect overwintering in the pupal state we shall be justified in believing from the facts available that in northerly latitudes *Musca domestica* is accustomed normally to overwinter in the adult state.

In more southerly latitudes, where the mean temperature is much higher and where the activity of the flies is practically continuous throughout the winter months, one would expect the occurrence of the insect in an active condition and of the various stages of its development during this period, although the duration of such developmental stages would be lengthened. This has been found to be the case in New Orleans, Florida, in the valuable investigation of the Bureau of Entomology of the United States, Department of Agriculture, according to the verbal statement of Mr. F. C. Bishopp.

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